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C4ISR Architecture Working Group (AWG)



Final Report

14 April 1998

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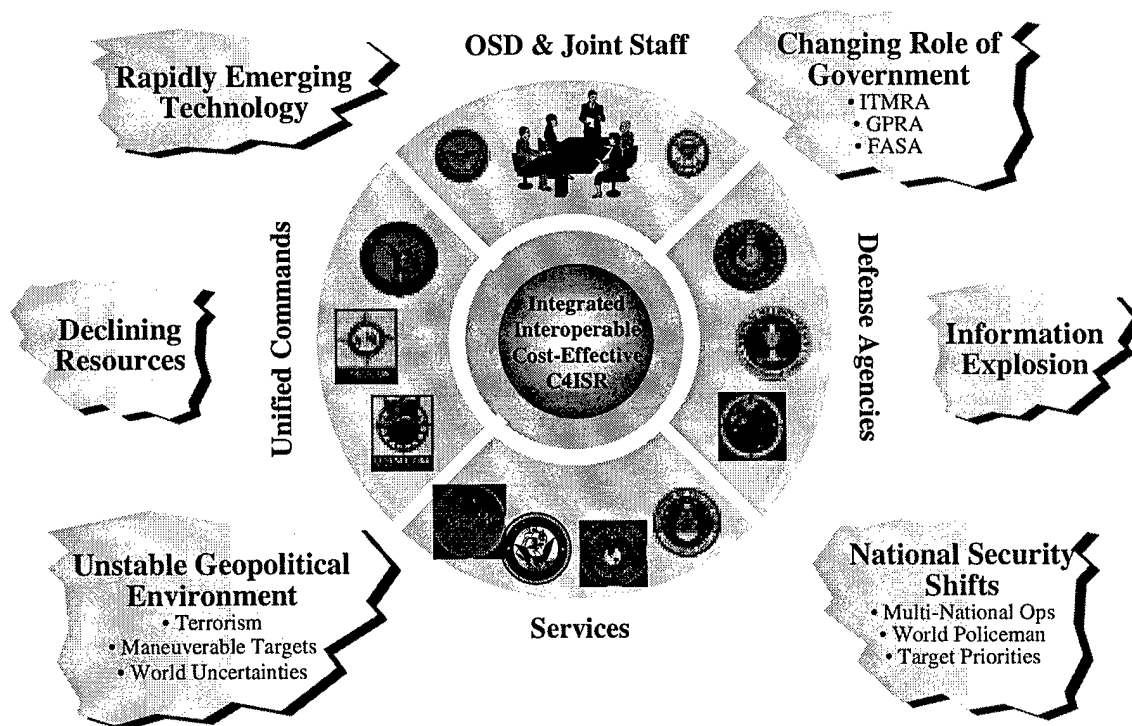
“Forces harnessing the capabilities potentially available from this [C4ISR] system-of-systems will gain dominant battlespace awareness, an interactive ‘picture’ which will yield much more accurate assessments of friendly and enemy operations within the area of interest. Although this will not eliminate the fog of war, dominant battlespace awareness will improve situational awareness, decrease response time, and make the battlespace considerably more transparent to those who achieve it.”

- Joint Vision 2010

Overview

In order to achieve the dominant battlespace awareness called for in Joint Vision 2010, today’s fragmented Command, Control, Communications, Computers, Intelligence Surveillance, and Reconnaissance (C4ISR) development processes must become more focused, efficient, and effective. The objective must be a joint C4ISR capability that is integrated, interoperable, efficient, and meets today’s demanding mission needs.

Many aspects of today’s environment place a premium on achieving the objective C4ISR capability outlined above.



The Challenge for DoD

The passing of the Cold War has resulted in a varied and uncertain threat environment, one that must be successfully met in the face of declining DoD budgets. These facets,

coupled with the information explosion enabled by the rapid emergence of information technology (e.g., the Internet), require that DoD put in place a means to acquire and implement C4ISR capabilities that are "born joint," interoperate across all boundaries at the levels of sophistication necessary to meet the mission need, provide an integrated, interactive "picture" of the battlespace, and can rapidly accommodate integration of emerging technologies and capabilities (e.g., computer processing, precise global positioning, telecommunications).

Furthermore, recent government legislation (e.g., the Information Technology Management Reform Act [ITMRA], also known as the Clinger-Cohen Act of 1996, and the Government Performance and Results Act of 1993 [GPRA]) is placing more emphasis on the need to pursue interoperable, integrated, and cost-effective business practices and capabilities within each organization and across DoD, particularly with respect to information technology. Together, the ITMRA and GPRA serve to codify the efficiency, interoperability, and leveraging goals being pursued by the Unified Commands, Services, and Agencies of DoD.

In 1995, DoD chartered a C4ISR Integration Task Force (ITF) comprised of the major Command, Service, and Agency stakeholders to define and develop better means and processes to ensure C4ISR capabilities most effectively meet warfighter needs. The ITF met that tasking by developing actionable recommendations to improve the key DoD processes (e.g., architectures, requirements, resource allocation, acquisition) that impact the ability of C4ISR to support warfighters and decision makers effectively.

On 18 October 1996, the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD[C3I]) and the Joint Staff, J6 chartered a C4ISR Architecture Working Group (AWG) to refine and extend the architecture and interoperability assessment recommendations put forward by the C4ISR ITF:

"The ... IAP ... developed very promising concepts and recommendations for the application of architectures to support the improved integration of C4ISR capabilities within DoD. We believe that most of the IAP recommendations warrant the eventual mandate of the Deputy Secretary of Defense ... we think it is prudent to establish a process ... that is intended to evolve, validate and mature ... the IAP's recommendations in a collaborative environment prior to formal mandate."

- Joint Staff (J6), PDASD(C3I)
18 October 1996

From the end of January through November 1997, the C4ISR AWG responded to the charge, and significantly evolved the products and recommendations established by the Integrated Architectures Panel (IAP) of the C4ISR ITF.

Scope

This document presents the accomplishments and final recommendations of the C4ISR Architectures Working Group (AWG).

AWG Organization

The AWG was co-chaired by the Director, Architectures Directorate of the C4ISR Integration Support Activity (CISA), and Joint Staff, J6I. It was comprised of representatives from each of the Services, the Unified Commands, several key Defense Agencies, and other invited organizations. Key participating organizations are listed below:

- OUSD(A&T), OASD(C3I), CISA
- Joint Staff (J2, J3, J6), the Joint Battle Center (JBC)
- USACOM, USEUCOM, USPACOM, USCENTCOM, USSOUTHCOM, USSOCOM, USTRANSCOM, USSTRATCOM, USSPACECOM
- Air Force (AFSC, AFCIC, AFCA, AFDSP, AFXO, AFXOI, AFXOCE, 497 IG)
- Army (ODISC4/OCIO/SAIS-PAA)
- Navy (N6, N20, SPAWAR)
- Marines (MCCDC)
- NIMA, CIA, DISA, DIA, DARO, NSA, NRO, ISS
- DoD Space Architect Organization
- BMDO, JTAMDO
- Coast Guard

The AWG organized its members into Panels (*Framework, Interoperability, Data Model and Analysis Tools, Roles and Responsibilities*) in order to address the following specific IAP recommendations:

- Establish common architecture terms and definitions
- Implement a common approach for architectures
- Strengthen architecture policy and guidance
- Define and use levels of interoperability
- Build architecture relationships with other DoD processes
- Manage DoD architectures

In addition to addressing specific IAP recommendations, the AWG established a *Multinational Force C4ISR Operations Panel* in order to capture issues relating to architecture development that cross-cut U.S. and multi-national force operations. A sixth panel, the *C4ISR AWG Integration Panel*, was established to guide, review, integrate, and make recommendations to the AWG on the work of the five Panels. The AWG presented its final recommendations to the DoD Architecture Coordination Council (ACC) on 18 December 1997.

AWG Highlights

Key C4ISR AWG accomplishments include the following:

- Common architecture terms and definitions and a common approach for architectures are established in the AWG's *C4ISR Architecture Framework, Version 2.0* and the *Core Architecture Data Model (CADM)*
- The definition, constructs, and process for the use of levels of interoperability have been refined and documented by the AWG in *The Levels of Information Systems Interoperability (LISI)* -- field validation is well under way
- Architecture policy, guidance, and relationships to formal DoD processes (e.g., requirements, PPBS, acquisition) are discussed in the AWG's *Roles and Responsibilities Report*, and are formalized in a DoD Policy Memorandum, Subject: Strategic Direction for a DoD Architecture Framework, signed by USD(A&T), ASD(C3I), and Joint Staff J6, dated 23 February 1998
- Inhibitors that restrict the successful execution of multinational force C4ISR operations are discussed in the *AWG Multinational Force C4ISR Operations White Paper*

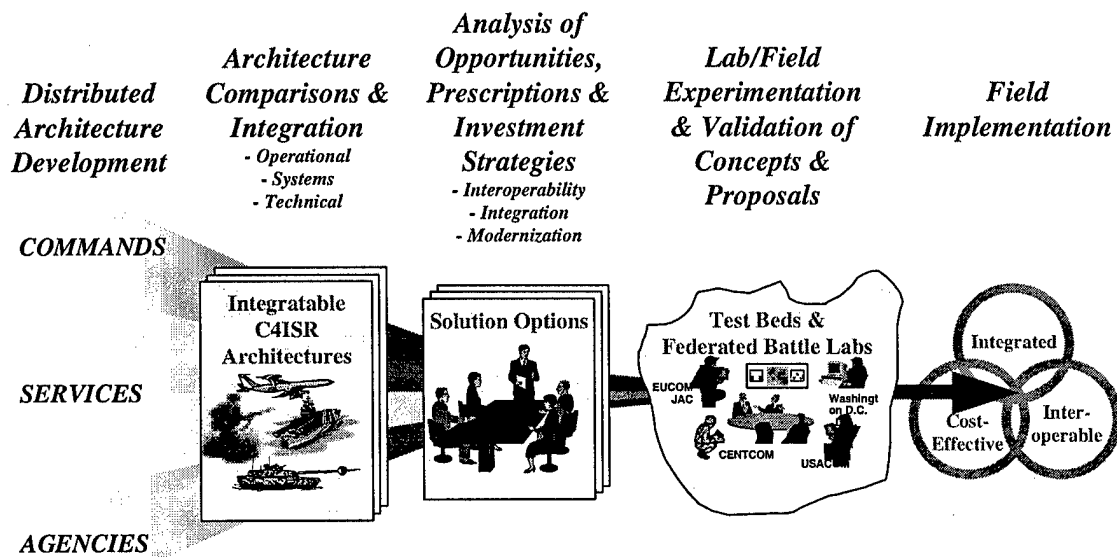
Key Architecture Working Group products can be found on the AWG Home Page. The URL is <http://www.cisa.osd.mil>

The remainder of this report presents the specific accomplishments and recommendations of the AWG and its Panels, and discusses each in terms of its impact on developing and fielding integrated, interoperable, and cost effective C4ISR capabilities that meet DoD's mission needs.

The Need – A Unified C4ISR Development Process

In order to field interoperable, integrated, and cost-effective C4ISR capabilities, DoD must establish a unified process that encompasses cross-domain architectural context, frameworks, and models; focused integration/interoperability assessment and testing processes, metrics, and measures of performance; and analysis to determine cost-effective solution options. Ideally, this unified process (see figure below) would work as follows:

- Distributed development of C4ISR operational, systems, and technical architecture views would continue
- Architectures would be easily compared and interrelated across organizational boundaries due to common look, touch, and feel
- The DoD components would leverage the integratable architecture(s) to:
 - Discuss and reconcile differences regarding common joint interactions
 - Examine applications of current and emerging technology
 - Look for leveraging opportunities
 - Identify and prioritize key systems interoperability problems and objectives
- Not-so-obvious concepts would be tested for validity and cost-effectiveness prior to committing to a potentially costly acquisition or full-scale integration activity
- Notions, ideas, concepts, limited demonstrations, and fielded capabilities could be traced back through the architecture audit trail to assess the impact on operational mission effectiveness



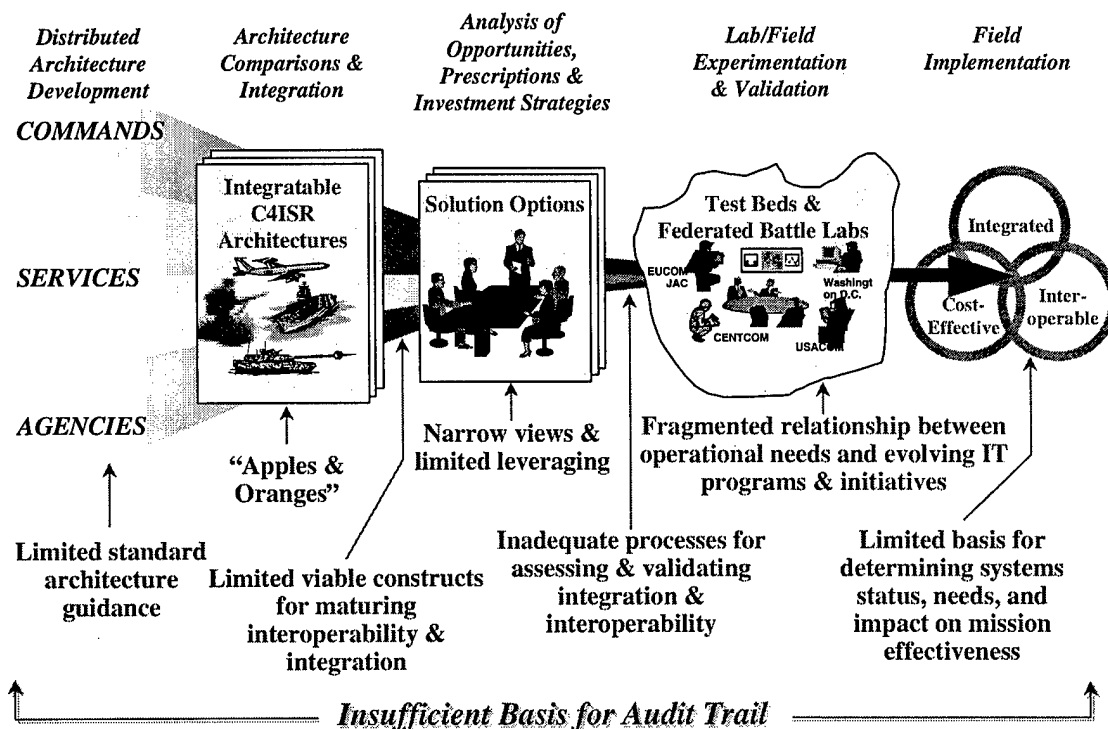
↑ *Basis for Audit Trail for Relating Systems \$\$ to Mission Effectiveness* ↓

Unified Process for Achieving Integrated, Interoperable, and Cost Effective C4ISR Capabilities

The Obstacles

Today, there are many obstacles that must be overcome in order for DoD to establish and implement a unified C4ISR development process. First, there is insufficient architecture development guidance enabling the DoD components to compare their individually described architecture views. Secondly, the existing definition of interoperability is too limited. It alludes to the fact that there are “degrees” of interoperability, but does not define what they are. In order to facilitate assessments and improvement strategies regarding systems interoperability, the community needs to recognize key distinctions in levels of information systems interaction and sophistication brought about by the nature of operational needline requirements and the differences in information systems capabilities due to affordability limitations. Finally, there are limited common, practical processes for integration and interoperability experimentation and testing.

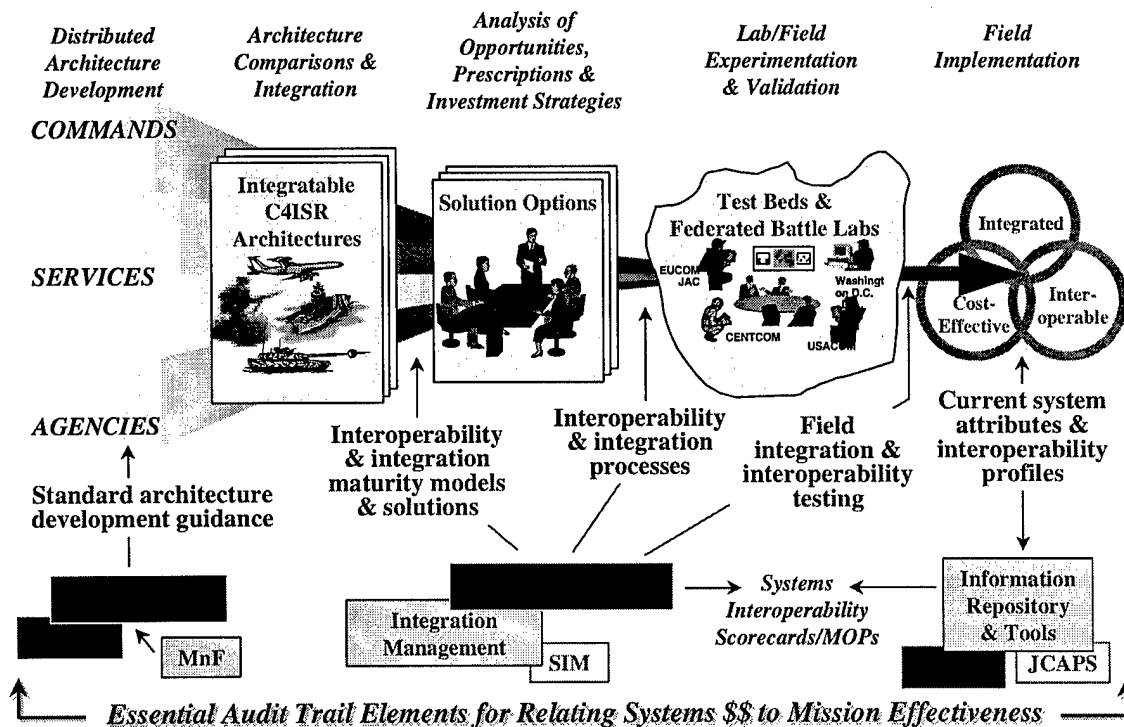
DoD’s ability, *as a community*, to analyze and find opportunities for increased integration, technology leveraging, and interoperability is further constrained by limited testing and knowledge of potential leveraging opportunities and very little basis for an audit trail to mission effectiveness.



Impediments to a Unified Process for Achieving Integrated, Interoperable, and Cost Effective C4ISR Capabilities

AWG Contributions

The C4ISR AWG products and associated recommendations to the ACC will mitigate many of the current impediments to achieving C4ISR integration, interoperability, and cost effectiveness (see figure below). The AWG products are evolutionary, and must continue to evolve as DoD and industry move forward. Furthermore, the AWG products have matured beyond the “concepts” stage, are actionable *now*, and must not wait for that infamous moving target called *perfection* to be attained.



AWG Contributions to a Unified Process for Achieving Integrated, Interoperable, and Cost Effective C4ISR Capabilities

The following paragraphs present specific Panel accomplishments and recommendations, in context with their contribution to a unified DoD process for achieving integrated, interoperable, and cost-effective C4ISR capabilities. The three critical AWG contributions are the *C4ISR Architecture Framework Version 2.0*, the *Levels of Information Systems Interoperability*, and the *C4ISR Core Architecture Data Model Version 1.0*. Other contributions include:

- ◆ The consideration of adapting a process such as the SIM process currently used by the DODIIS community to a DoD-wide Integration Management process
- ◆ The identification of inhibitors to effective C4ISR interaction with multi-national force partners
- ◆ The assessment of a C4ISR information repository and tools, including the consideration of JCAPS as a front end

Framework Panel

Framework Panel Objectives

The primary objectives of the Framework Panel were:

- Collect lessons-learned from the use of the *Framework V1.0*
- Define the evolution of the *Framework* to V2.0
- Gain consensus on the use of *Framework V2.0* throughout the DoD
- Make appropriate recommendations on the *Framework* to the ACC and other DoD organizations

Framework Panel Tasks Accomplished

The Framework Panel was co-chaired by Air Force (HQ USAF/SCTA), and Navy (SPAWAR). Panel membership consisted of representatives from Unified Command/Service/Agency (C/S/A) organizations that are actively involved in the development and use of architectures to support various purposes across the DoD. The Framework Panel focused its efforts on the following tasks, considering each in context with its impact on evolving the *C4ISR Architecture Framework* from Version 1.0 to Version 2.0:

- Gather lessons-learned and experiences from the C/S/As in the use of Framework V1.0
- Identify documents within the DoD involving architecture development and use, to include the JTA, TAFIM, DII COE, etc., to determine the relationships of these activities and documents with respect to evolving the C4ISR Architectures Framework to V2.0
- Determine the use of the Levels of Information System Interoperability (LISI) construct within the Framework process
- Derive the new products or process changes to be incorporated into the Framework V2.0.
- Examine the C4ISR data model, architecture development tools and other related activities as appropriate to the Framework process
- Define the evolution of the Framework beyond V2.0 with respect to the use of new technology and information constructs and gain consensus on mandating the Framework for DoD use

As a result of performing these tasks, the Panel has collectively developed a *C4ISR Architecture Framework Version 2.0* that builds on Version 1.0 by specifying an enriched set of architecture product types with comparable information content. A data model for representing that information content is included. Framework 2.0 also ensures consistent use of architecture terminology.

In general, the transition from Framework V1.0 to Framework V2.0 was driven by key lessons learned from use of V1.0 that were brought forward by the Panel members. For a

complete treatment of community lessons learned, see CISA's *C4ISR Architecture Framework, V1.0, Lessons Learned and Issues for Consideration* document. Some of the key lessons learned are highlighted below:

- Additional products are needed to describe the systems architecture view
- Products should be added that describe the behavioral aspects of an architecture (e.g., timing and sequencing of actions)
- Compliance criteria regarding the Framework guidance need to be articulated (i.e., mandatory vs. discretionary)
- The degree of latitude that can be exercised in interpreting product guidelines must be more clearly delineated
- Architects need a clear distinction between the products they must create versus those that they must consult
- Architects are looking for a set of "how to build" instructions for architecture descriptions

As a result of these lessons learned and the knowledge gained through performance of the above Panel tasks, several key changes were incorporated into the C4ISR Architecture Framework Version 2.0. The following paragraphs highlight several key changes.

Version 2.0 now includes 26 specific product types that collectively encompass the operational, systems, and technical architecture views. These product types are classified in two categories, essential and supporting. Essential products *"constitute the minimal set of products required to develop architectures that can be commonly understood and integrated within and across DoD organizational boundaries and between DoD and multi-national elements. These products must be developed for all architectures."* Supporting products *"provide data that will be needed depending on the purpose and objectives of a specific architecture effort. Appropriate products from the supporting product set will be developed depending on the purpose and objectives of the architecture."*

Version 2.0 offers specific compliance guidelines. In order to comply with the Framework, architectures must:

- Provide the specified, minimum set of essential products
- Use specified standardized supporting products when needed
- Use the common terms and definitions as specified in the Framework document
- Describe Joint and multi-national relationships in a standard way
- Describe interoperability requirements in a standard way

Version 2.0 specifies a six-step architecture description process. This process begins with a critical first step that has often been overlooked in previous architecture development efforts -- determine the intended use of the architecture.

Version 2.0 now cites the *C4ISR Core Architecture Data Model (CADM)* developed by the Data Models and Analysis Tools Panel and the *Levels of Information Systems*

Interoperability (LISI) process developed by the Interoperability Panel as Universal Reference Resources for architects to consult in the development of architecture descriptions. Universal Reference Resources (e.g., CADM, LISI, UJTL, DII COE, JTA) are reference models and information standards that serve as sources for guidelines and attributes that must be consulted while building architecture products.

Framework Panel Summary

In summary, the *C4ISR Architecture Framework*, Version 2.0, developed through the Panel's consensus-based process, now provides uniform guidance for describing architectures that can be compared and integrated and the audit trail for tracing system capabilities to impacts on operational mission effectiveness. Version 2.0 is ready for institutionalization as the strategic direction and guidance for architecture development in DoD.

Framework Panel Recommendations to the AWG

Specific Panel recommendations to the AWG are as follows:

- Incorporate *C4ISR Architecture Framework Version 2.0* into the AWG Final Report.
- Institutionalize the Framework as the strategic direction for architecture development throughout DoD

Data Models and Analysis Tools Panel

DMAT Panel Objectives

The primary objectives of the Data Models and Analysis Tools Panel were:

- Reach agreement across the C/S/As on a standard logical data model to address C4ISR architecture information content and data interactions.
- Reach agreement on the standard data analysis capabilities/tools for use within the C4ISR architecture arena.

DMAT Panel Tasks Accomplished

The C4ISR Data Model and Analysis Tools (DMAT) Panel was co-chaired by CISA AD and Navy/SPAWAR. Panel membership consisted of representatives from C/S/A organizations that are actively involved in the development of data requirement specifications for the essential elements of information to be contained in C4ISR architectures. The DMAT Panel focused its efforts on the following tasks:

- Construct a prototype Core C4ISR Architecture Data Model (CADM)
- Assess the degree to which the CADM meets the information needs expressed in the *C4ISR Architecture Framework*
- Determine an appropriate segmentation of tool functionality to support architecture development and analysis
- Create an example profile of architecture tool types and DoD standards directly tied to *Framework* products
- Identify existing tools to determine the potential for the creation of a common architecture tool suite to support the C/S/As

As a result of the knowledge gained through the performance of these tasks, the DMAT Panel developed the C4ISR Core Architecture Data Model (CADM), Version 1.0. The CADM is a logical data model designed to provide a common approach for organizing and portraying the structure of architecture information. As a logical model, the CADM provides a conceptual view of how architecture information is organized, rather than a description of how the data is actually stored in an actual database implementation. CADM development included decomposition of many high-level, composite data structures found in existing architecture databases and data models (e.g., Navy C4ISR Architecture Data Model, Air Force ITM V2 Logical Data Model, NIMA USIGS Framework, Marine Corps ArchVision Data Model, Army COE Architecture Data Model) in order to isolate single-concept entities and attributes. Development also included use, wherever possible, of approved data structures of the DoD Data Model and approved definitions in the DoD Data Dictionary System (DDDS). For further details regarding the CADM, see the AWG's *C4ISR Core Architecture Data Model Version 1.0*, dated 15 September 1997.

As described above, DMAT Panel efforts focused primarily on data models. However, the DMAT Panel also made progress in the identification of tool functionality, types, and pertinent DoD standards. Architecture tool functionality was categorized into the following areas:

- Management
- Analysis
- Development Support
- Costing
- Data Management
- Import & Export

For each area, example profiles of tool types and standards were generated to show how a *Framework* product would be tied to a tool type, standard application platform service, and sample software application. These profiles could then be used to manage the use of tools and their applicability to a particular *Framework* product. The Joint C4ISR Architecture Planning System (JCAPS), currently under development by CISA, was offered as a basis for evolving, via a COTS integration process, the common architecture tool suite for use by the C/S/As.

DMAT Panel Summary

In summary, the *C4ISR Architecture Data Model Version 1.0* defines standard architecture attributes and data that correspond to the *Framework's* architecture products. CADM attribute/data definitions are "in sync" with those already defined in the DoD Data Dictionary. For attributes/data not already defined in the DoD Data Dictionary, the CADM offers candidate definitions for inclusion. For a detailed discussion of DMAT Panel contributions, see the *DMAT Panel Final Report*, dated 12 December 1997.

In order to continue evolving the CADM and the development of a C4ISR architecture development tool suite, the DMAT Panel proposes several key follow-on activities for ACC consideration. These activities include:

- Map the product types specified in the C4ISR Architecture Framework Version 2.0 into the CADM
- Prioritize and address CADM extensions (e.g., object models, state transition specifications, development costs, and system specifications)
- Incorporate lessons learned from C/S/A CADM implementers to ensure CADM validation
- Establish a body to pursue the development of architecture analysis and generation tools

DMAT Panel Recommendations to the AWG

Specific DMAT Panel recommendations to the AWG are as follows:

- Incorporate the *C4ISR Core Architecture Data Model Version 1.0* into the AWG Final Report
- Validate the CADM against the *C4ISR Architecture Framework Version 2.0* and against any future versions of the Framework document, under the auspices of the ACC
- Institute the CADM as the logical data model schema for any C4ISR architecture development effort based on the *Framework*
- Assign stewardship and provide resources for CADM evolution (the Panel agreed that the Functional Data Administrator [FDAD] for ASD(C3I) should be the steward)
- Establish repositories for the CADM and identify what policies are applied to govern populating data repositories; who populates the data repositories; and continued maintenance of the data repositories
- Establish a body to pursue architecture development and analysis tools

Multinational Force Operations Panel

MnF Panel Objectives

The objective of the Multi-national Force C4ISR Operations Panel is to define, integrate, categorize and prioritize the inhibitors that restrict the successful execution of Multi-national Force (MnF) C4ISR operations. Further, the Panel was charged to develop recommendations to the AWG on how DoD should proceed to ensure that the critical inhibitors are properly addressed and resolved from both the DoD policy and Command perspectives.

MnF Panel Tasks Accomplished

The MnF C4ISR Operations Panel was co-chaired by CISA-IAD and Joint Staff J-6V. Panel membership consisted of representatives from each of the Unified Commands. Selected allies were invited to participate in selected Panel meetings as deemed appropriate by the AWG to ensure success in meeting Panel objectives.

In determining the inhibitors to effective MnF C4ISR operations, the Panel made the following assumptions:

- ◆ Successful MnF C4ISR operations require integration and interoperability
- ◆ OSD, Services, and Defense Agencies have traditionally focused their multi-national operations concerns on NATO
- ◆ A comprehensive statement of factors that inhibit interoperability from the Unified Commands and our MnF partners does not exist
- ◆ A lack of a single Washington-based forum to integrate and address the interdependencies of the different MnF issues

Based on these assumptions, the Panel identified specific inhibitors within six major categories: doctrine and policy, acquisition and logistics, information management, technology, culture, and training and exercises. For a detailed discussion of the inhibitors and the Panel's specific recommendations for addressing the inhibitors, see *the Multi-national Force C4ISR Operations White Paper*, dated 11 December 1997.

MnF Panel Summary

The *Multi-national Force C4ISR Operations White Paper* describes major issues that the DoD architect must be cognizant of when addressing U.S.- external C4ISR architecture relationships.

MnF Panel Recommendations to the AWG

The Multinational Forces C4ISR Operations Panel recommends that the AWG forward the Panel's *MnF C4ISR Operations White Paper* to the ACC.

Interoperability Panel

Interoperability Panel Objectives

The Interoperability Panel objective was to refine the current *LISI* construct into a discipline and process that supports developing, certifying, fielding, and maturing C4ISR information systems -- ensuring that each system has the degree of interoperability needed to support current and potential joint mission requirements.

Interoperability Panel Tasks Accomplished

The Interoperability Panel was co-chaired by Joint Staff J-6I and DISA. Panel membership included representatives from OSD, Joint Staff, and the C/S/As who are actively involved in C4ISR systems development and implementation.

The Interoperability Panel focused its efforts on accomplishing the following tasks:

- Refine the *Levels of Information Systems Interoperability (LISI)* concept into a discipline and process for defining, evaluating, measuring, and certifying information system interoperability using a common frame of reference and measure of performance
- Decide and act on the degree of policy institutionalization that should govern C/S/A use of LISI (e.g., DoDD 5000, 8000 series, DoDI 4630.5, 4630.8).
- Define specific relationships between LISI and the prevailing DoD and multinational information technology initiatives (e.g., DII COE, JTA, TAFIM, NATO System Interconnection Levels)
- Delineate the specific relationships between LISI and the *C4ISR Architecture Framework Version 2.0*

To accomplish these goals, the work on the LISI project began by leveraging from the work done in 1993 through 1996. LISI now incorporates existing and emerging information technology advances, cross references essential information for developers from the DII COE and the JTA, and covers new areas, such as the advent of the Internet and the evolving Web-based computing environment.

As a result of its efforts, the Interoperability Panel delivered the following products to the AWG in August 1997:

- ◆ The LISI Reference Model
- ◆ Appendix D, "*Levels of Information Systems Interoperability Reference Model*", to the C4ISR Architecture Framework, Version 2.0
- ◆ Recommendations for Policy Insertion (e.g., DoDD 4630.5) to AWG Roles and Responsibility Panel
- ◆ Mapping of LISI and JTA, DII COE, DII Master Plan

Interoperability Panel Summary

The Interoperability Panel's chief contribution to a "Unified Process for Achieving Integrated, Interoperable, and Cost Effective C4ISR Capabilities" is the *Levels of Information Systems Interoperability (LISI)*.

LISI currently provides:

- An *interoperability maturity model* that describes increasing levels of sophistication regarding the ability of systems to exchange information with each other
- The ability to identify *operational and system requirements* in terms of specific levels of interoperability by examining the nature of required mission-related information transactions in context with the levels defined in the *interoperability maturity model*
- The *suite of capabilities* associated with procedures, applications, infrastructure, and data that must be inherent in an information system to achieve each level of interoperability
- The *implementation options* that are available for each prescribed capability, including clear distinctions between those options that conform with current DoD technical criteria (e.g., JTA, DII COE, SHADE, ...) and those that do not
- A practical *assessment process* for determining the interoperability maturity level of a given system or system pair, capabilities that may be lacking, implementations that are not compatible, and options available for resolving deficiencies and for achieving progressively higher levels of maturity
- A *collaborative means* for the community to work together to resolve system-to-system disconnects and evolutionary strategies, and to engage with formal standards bodies to provide constructive feedback regarding the currency and feasibility of existing implementation guidance

For a detailed description of LISI, see the *Levels of Information Systems Interoperability* document, dated February 1998.

Interoperability Panel Recommendations to the AWG

Specific Interoperability Panel recommendations to the AWG are as follows:

- Continue the LISI refinement and publish version one of the tool by April 1998. (Joint Staff/DISA/CISA/MITRE combined effort)
- LISI should be institutionalized in DoD policy (4630/5000 series). The Joint Staff will lead the initial effort.
- The Joint Staff will lead the short-term promulgation of LISI to DoD, MnF, US government. ASD(C3I) will assist as necessary.
- ASD(C3I) will be responsible for the long term policy, oversight, and promulgation of LISI
- DISA (D68) will perform LISI information maintenance and customer services.
- The JBC and Federated Battle Labs will act as primary assessment and validation forums for LISI.

- Include LISI as part of the AWG final report.

Roles and Responsibilities Panel

R&R Panel Objective

The objective of the Roles & Responsibilities Panel was to define organizational roles and responsibilities for C4ISR architecture development and integration in context with a process for effectively applying architectures to support the improved integration of C4ISR capabilities across DoD.

R&R Panel Tasks Accomplished

The Roles & Responsibilities Panel was co-chaired by Army (HQ DA DISC4) and CISA-AD. Panel composition included representatives from OSD, Joint Staff, and the C/S/As who are actively involved in architecture development and use.

The Panel derived its tasking from the following specific C4ISR Integration Task Force (ITF) recommendations:

- Ensure that relevant Department directives and instructions are changed to implement the C4ISR Architecture Framework as direction for developing and presenting C4ISR architectures
- Analyze the use of architectures in other DoD processes; most notably the requirements, resource allocation, and acquisition processes
- Identify the DoD Directives and Instructions that must be modified or written to define a formal process for managing architectures and articulate the relationship between architectures and the Joint Strategic Planning System (JSPS), the Planning, Programming, and Budgeting System (PPBS), and the Acquisition System
- Determine the feasibility of DoD-wide implementation of the Systems Integration Management (SIM) process currently in use by the DoD Intelligence Information System (DODIIS) community

The Panel reviewed ten major DoD and Joint Staff directives and guidance documents over the course of its existence. The Panel also oversaw the conduct of a feasibility study of the implementation of a "DODIIS-like" SIM implementation across DoD. Also, the Panel assisted the Integration Panel in the selection and development of an implementation vehicle (DoD Policy Memorandum) for the C4ISR Architecture Framework Version 2.0. Detailed Panel results are documented in the *Roles & Responsibilities Panel Final Report*, dated 19 November 1997.

R&R Panel Summary

The *Roles and Responsibilities Panel Report* prescribes the way ahead for future architectural development and integration within the Department. Investigations into

systems integration approaches have also begun, with the DoDIIS Systems Integration Management (SIM) process being a candidate for community-wide adaptation. Preliminary work has also begun regarding architecture databases and tools. The Joint C4ISR Architecture Planning System (JCAPS) is a candidate for addressing this need.

R&R Panel Recommendations to the AWG

Specific Roles and Responsibilities Panel recommendations to the AWG are as follows:

- The DoD CIO should develop a DoD Architecture Strategy that describes the purposes, definition, scope, and goals/objectives of the DoD ITA
- The DoD CIO should determine the relationships among the DoD architecture process and the core DoD business processes, using an integrated concept team that includes representatives from the JCS, CINCs, Services, and Defense Agencies
- The DoD CIO should develop an Overarching DoD Architecture Policy that identifies architecture roles/responsibilities and a DoD enterprise-level architecture process that specifies how architectures will be managed, used, and enforced in the core DoD business processes (requirements, resource allocation, and acquisition)
- The DoD CIO should develop a comprehensive set of instructions regarding how to describe architectures for the pertinent domains within DoD – a logical extension of the current *C4ISR Architecture Framework*
- A DoD architecture control mechanism should be established, including and involving the present DAB, MAISRC, ACC, DoD CIO Council, etc., to ensure that DoD IT systems are built and maintained within the appropriate DoD architectural context
- The CINC's, Services and Agencies advocate the Panel's suggested "line-by-line" changes to current DoD policy directives and instructions that would make them consistent with the above recommendations

Integration Panel

Integration Panel Objectives

The C4ISR AWG Integration Panel objective was, on behalf of the full C4ISR AWG, to guide, review, and integrate the work of all established AWG Panels. The Integration Panel was also responsible for keeping the AWG membership apprised of progress and issues that emanated from the work of all established panels. In addition, the Integration Panel reported to the ACC or other appropriate authorities as required between meetings of the full AWG. Finally, the Integration Panel ensured that the work of all Panels was completed, integrated, and brought to the full C4ISR AWG for review, revision as necessary, and approval, for forwarding to the Architecture Coordination Council.

Integration Panel Tasks Accomplished

The Integration Panel was co-chaired by the Co-Chairpersons of the C4ISR AWG. The membership of the Integration Panel consisted of the Co-Chairs of all established C4ISR AWG Panels, the Executive Secretaries of the AWG and each of the Panels, and the Co-Chairmen of the C4ISR ITF Integrated Architecture Panel.

The Integration Panel focused its efforts in several key areas, including:

- ◆ Ensuring that each of the Panel products was developed in context with its impact on the efforts and products of the other Panels
- ◆ Determining the way ahead (beyond AWG) for each of the key AWG contributions to a unified C4ISR development process
- ◆ Addressing issues regarding the impact of AWG products and contributions on current DoD architecture and IT initiatives

The Integration Panel has identified several issues that must be resolved to ensure that critical AWG contributions continue to evolve and effectively meet DoD needs. Key issues are highlighted below:

Architectures

- ◆ What is the process for ensuring continued involvement of the Unified Commands in the development and evolution of C4ISR architecture policy, guidance tools, etc.?
- ◆ What are the measures of effectiveness for the “goodness” of architectures?
- ◆ Who will have stewardship of the C4ISR Architecture Framework?
- ◆ How will the Framework expand from C4ISR to Multi-domain applicability?
- ◆ What is the process for conducting architecture training across the DoD community?
- ◆ What is the appropriate scope, orientation, and level of detail for the Joint Operational Architecture (JOA) and the Joint Systems Architecture (JSA)? What are their relationships with current and future C/S/A architectures? Who will have stewardship of and development responsibility for the JOA and JSA?

Interoperability Assessment

- ◆ What is the basis for evolving domain (DoD, Federal, Multi-national) implementation criteria and rule sets (e.g., JTA) in context with LISI systems interoperability assessments?
- ◆ How will LISI be institutionalized as a DoD-wide interoperability assessment process? What is the supporting management structure? What are the roles of supporting and related organizations (e.g., JBC, JITC, etc.)?
- ◆ Who will have stewardship of LISI?

Integration Management

- ◆ What is the DoD-wide process for Systems Integration Management (SIM)? Can the DODIIS community's SIM process be adapted for DoD-wide applicability?

Information Repository/Tools

- ◆ What are the procedures for classification of and access to an aggregated C4ISR architecture information data base?
- ◆ How will the Joint C4ISR Architecture Planning System (JCAPS) evolve to become the C4ISR architecture information repository and tool suite?

In addition to the issues identified above, the Integration Panel developed AWG findings regarding several key DoD architecture and IT initiatives that would be impacted as a result of key AWG products. Key findings are presented in the following paragraphs.

Consistent with the evolution of several key architecture initiatives (e.g., C4ISR Architecture Framework, JTA), the AWG developed a set of recommendations regarding future disposition of the DoD Technical Architecture Framework for Information Management (TAFIM). The TAFIM is currently organized as follows:

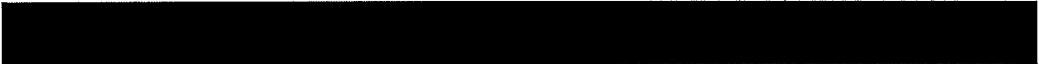
- ◆ Volume 1: Overview
- ◆ Volume 2: Technical Reference Model
- ◆ Volume 3: Architecture Concepts & Design Guidance
- ◆ Volume 4: DoD Standards-Based Architecture Planning Guide
- ◆ Volume 5: Program Manager's Guide for Open Systems
- ◆ Volume 6: DoD Goal Security Architecture
- ◆ Volume 7: Adopted Information Technology Standards
- ◆ Volume 8: Human Computer Interface Style Guide

The AWG's specific recommendations regarding the disposition of each volume of the TAFIM are:

TAFIM Volume 1	Eliminate	Recommend umbrella structure needed; probably through ASD(C3I) for C4ISR or ACC Secretariat
TAFIM Volume 2	Keep	Currently included as an Appendix to the C4ISR Architecture Framework; recommend ACC publish separately as DoD TRM
TAFIM Volume 3	Eliminate	Conceptual evolution since time of original writing has been captured in Framework Version 2.0
TAFIM Volume 4	Eliminate	ACC should lead continuing discussions regarding additional policy and guidance that may be needed
TAFIM Volume 5	Eliminate	ACC should lead continuing discussions leading to recommendations on policy and guidance impacts
TAFIM Volume 6	Eliminate	Recommend ACC provide comments on requirement for additional guidance
TAFIM Volume 7	Eliminate	Replaced by JTA
TAFIM Volume 8	Merge	Merge with DII Style Guide

In accordance with the Clinger-Cohen Act and Office of Management and Budget (OMB) memorandum M-97-16, the DoD CIO must build an agency-wide model for Information Technology Architecture with a Technical Reference Model and Standards. This DoD-wide model would be used in all information technology acquisitions. At this time DoD does not have such a model. The AWG recommends the establishment of a multi-domain architecture working group with appropriate DoD community-wide representation whose charter would be to support the DoD CIO in developing a DoD Information Technology Architecture.

In 1997, the DoD Inspector General (IG) conducted an audit of the Joint Technical Architecture (JTA). The major findings are shown in the figure below.

- ✓ * **Develop a methodology for cross-Service and cross-functional coordination of Component Joint Technical Architecture implementation plans**
 - ✓ * **Develop a methodology to measure and track Joint Technical Architecture implementation progress and success**
 - ✓ * **Disseminate information periodically regarding factors that could impede or enhance Joint Technical Architecture implementation**
 - * **Establish review mechanisms to periodically assess joint interoperability levels**
- 

DoD IG Findings Regarding the Joint Technical Architecture

Regarding the fourth IG finding, the AWG recommends the adoption of the Levels of Information Systems Interoperability (LISI) as a key part of the overall process for conducting DoD-wide interoperability assessments.

In order to ensure the successful evolution of the key AWG products, the issues and recommendations cited above by the Integration Panel must be addressed and resolved by the ACC. Furthermore, the ACC should enlist direct, DoD community-wide participation in addressing these issues and recommendations.

Integration Panel Recommendations to the AWG

- ◆ **Establish an Architectures Coordination Group (ACG).**

The areas within DoD in which architectures could contribute measurably to the roles of integration and interoperability, insertion of technology, and cost reduction are indeed large. This work requires very senior level attention, but only periodically. DoD architecture work also requires continuous guidance, review and integration at a lower level than the ACC. The AWG proposes that the primary purpose of the Architectures Coordination Group (ACG) should be to serve as the action arm of the ACC, i.e., provide continuous support to the ACC and to the ACC's program of work. To a large extent, this means to guide, review, and integrate the work of different ACC support entities on behalf of the ACC between the meetings of the ACC.

Accordingly, the AWG recommends that the ACC Executive Secretaries serve as the Co-Chairmen of the ACG. ACG membership should include the Co-Chairs of established ACC support entities, e.g., the Co-Chairs of the TASG. Further, the ACG agenda

should cover many functional topics (e.g., C4ISR, weapons systems, sustainment), different architecture views (operational, systems, and technical), and architectures from different organizations, i.e., the C/S/As. Depending on the ACG topic under consideration, each organization represented at the ACG should have its appropriate topic expert serving in the ACG. Further, the AWG is proud of the role and contributions of the Unified Commands in the development of its products. Unified Command representation in the ACG should be fully encouraged. Finally, other organizations that may have a stake in the topics being addressed by the ACG should be part of its membership.

In context with its recommendation, the Integration Panel proposes the following Terms of Reference as the basis for establishing the Architecture Coordination Group (ACG).

Proposed Architecture Coordination Group (ACG) Terms of Reference

Mission: Provide continuous support to the ACC and its program of work to ensure architectures contribute measurably to integration & interoperability, insertion of new technology, and cost reduction

Functions: The ACG will serve as the executive secretariat of the ACC, and ensure that all work of the ACC and its support groups is completed, integrated, and brought to the ACC for appropriate review, revision, and approval. The ACG co-chairman will serve as the ACC Executive Secretaries. The ACG will accomplish any task assigned to it by the ACC. In addition, specific examples of functions to be accomplished include:

- ◆ Provide ongoing guidance, review, and integration to ACC program of work between ACC meetings -- and provide status reports to the ACC
- ◆ Ensure evolutionary, balanced ACC program of work and identify key issues for ACC consideration (all major functional areas; operations/systems/technical; C/S/A)
- ◆ Develop consensus on DoD architecture structures, processes and tools
- ◆ Review selected architectures developed by the Unified Commands, Services, and the Defense Agencies
- ◆ Ensure that DoD architectures contribute significantly to the achievement of integration and interoperability, insertion of new technology, and the reduction of life cycle costs within and amongst DoD entities, and between the U.S. and multi-national force partners

Composition: ACC Executive Secretariat would serve as Co-Chairs of the ACG. ACG membership would include:

- ◆ Co-Chairs of all other ACC established support entities (e.g., TASG, JOAWG, etc.)
- ◆ Topic expert representatives (O6/GM-15 or higher grade) from each ACC member organization
- ◆ Unified Command representation encouraged
- ◆ Others as designated by the ACC

Some proposed actions for immediate ACG focus include:

- ◆ Develop the DoD strategy for development, management, and use of architectures -- to include the establishment of metrics for value-added to the warfighter and the investment decision process
- ◆ Continue evolution of the *C4ISR Architecture Framework* and facilitating tools -- to include development and institutionalization of appropriate training
- ◆ Extend the *C4ISR Architecture Framework* to DoD-wide application
- ◆ Undertake the DoD IG recommendation to establish review mechanisms to periodically assess interoperability levels, using the *Levels of Information Systems Interoperability (LISI)*
- ◆ Evolve the *C4ISR Core Architecture Data Model* and investigate data analysis tools
- ◆ Pursue application of an integration process across DoD C4ISR

Conclusion

Implementation Actions

The AWG recommends that the ACC undertake the following actions:

- Institutionalize the *C4ISR Architecture Framework, Version 2.0*, via DoD Policy Memorandum and changes to major Department Directives and Regulations
- Charge ASD(C3I) and Joint Staff to continue evolutionary implementation of the *Levels of Information Systems Interoperability (LISI)*
- Establish the *Architectures Coordination Group*

Though many organizations are already using the Framework informally, institutionalization is critically needed to make its use universal. Regular use of the Framework across the C4ISR community, including the allocation of resources necessary to be compliant, is contingent upon the Framework being formally institutionalized.

LISI is rapidly gaining in acceptance and use across the community. However, the lack of formal policy regarding the application of LISI is discouraging many organizations from committing resources to use LISI on a routine basis. LISI roles and responsibilities need to be coordinated in context with other interoperability assurance efforts, and a concept for LISI's management and application must be developed as a prerequisite to pursuing policy measures.

Establishing the Architecture Coordination Group (ACG) is critical to continue the accomplishments of the C4ISR AWG and to support the priorities of the ACC as they emerge.

AWG Key Product Summary

The following list represents the key products developed by the AWG during its tenure. Each product can be found on the AWG Home Page located at <http://www.cisa.osd.mil>

- C4ISR Architecture Framework Version 2.0, 18 December 1997
- C4ISR Core Architecture Data Model Version 1.0, 15 September 1997
- Levels of Information Systems Interoperability Document, 30 January 1998
- Multi-national Force C4ISR Operations White Paper, 11 December 1997
- Roles & Responsibilities Panel Final Report, 19 November 1997
- Data Models & Analysis Tools Panel Final Report, 12 December 1997

Annex A: Architecture Working Group Member Organizations

DoD Organizations

OASD(C3I)/C3
OUSD(A&T)(OS-JTF)
OASD(C3I)/CISA
DASD (C31A, P&R)
Joint Staff (J2, J3, J6)
Joint Battle Center

Unified Commands and Subordinate Elements

USACOM (J6, J612A, J612E, J2P, J22A1)
USEUCOM(ECJ6-O, ECJ2/P)
USPACOM (J2, J62)
USCENTCOM (CCJ3, CCJ2, CCJ6)
USSOUTHCOM (J2, J6)
USSOCOM (SOIO-IN, SOIO-C4I, SOIO-C4I-PS, SOIO-C4I-EA)
USTRANSCOM (TCJ2, TCJ3/4, TCJ6)
USSTRATCOM (J2, J363, J614, J61)
USSPACECOM (J51)
NORAD
Atlantic Intelligence Command

Services and Subordinate Elements

Air Force (AFSC, AFCIC, AFCA, AFDSP0, AFXO, AFXOI, AFXOCE, 497IG)
HQAFCIC /ITA, XOII, SCTA, XORI
Army (ODISC4/OCIO/SAIS-PAA, Architectures Directorate)
NAVY (N6, N20, N62, SPAWAR, JMCIS,OPNAV-N6C)
Marines (MCCDC)
US Coast Guard (G-OCC)
Air Force STEM-J

Defense Agencies and Organizations

DISA (D631, JEB, D-5, JEXF, EUR/EU5, Joint Interoperability Test Command)
DIA (DM-4, SYA-1, S4A, CL-3B, DS-MBI)
DOD Joint Spectrum Center
DODIIS Management Board (DMB)
DARO
DoD Space Architect Organization

Ballistic Missile Defense Organization (DE)
NSA (P121, Unified Cryptographic Architecture [UCA])
NRO
NIMA (SEI, SEIT, NPI, ST, CF, AR, NP)
Joint National Test Facility
Joint Strike Program Office/C4I Integrated Product Team
JTAMDO

Other US Government Organizations

Intelligence Systems Secretariat (ISS)
CIA

FFRDCs

MITRE Corporation
Institute for Defense Analyses (IDA) (CISA, BMDO/DE)
Aerospace Corporation